CI/SfB Yq4
Issue 5 October 2023
(SUPERSEDES Issue 4 September 2021)

The use of ground granulated blastfurnace slag and fly ash in mortar

General Information

The use of ground granulated blastfurnace slag (ggbs) and fly ash in mortar has increased in recent years. Records indicate that blastfurnace cement was used for the mortar during the construction of the Empire State Building in the 1930s. Fly ash has been used as a constituent material of mortars for over thirty years, and in the case of some of the bagged proprietary mortars for an even longer period.

These materials not only impart technical benefits to both the fresh and hardened properties of mortar they are also environmentally friendly. Both materials are products resulting from industrial processes and their use, therefore, reduces the quantity of primary raw materials that have to be extracted from the ground. Ground granulated blastfurnace slag is classified as a latent hydraulic material. This means that it has inherent cementitious properties, but these have to be activated. The normal means of achieving this is to combine the material with Portland cement. Fly ash is classified as a pozzolana. This type of material does not generally have inherent cementitious properties, but if it is combined with a highly alkaline material it forms a cementitious product.

Gound granulated blastfurnace slag (ggbs)

Production

During the manufacture of iron, blastfurnace slag is produced as a by-product. This material is rapidly cooled to form a granulate and then ground to a fine white powder (ggbs), which has many similar characteristics to Portland cement. When ggbs is blended with Portland cement further recognised cementitious materials such as Portland-slag cement and blastfurnace cement are produced. In the UK, ggbs is manufactured and generally sold as a separate powder which is then batched and blended within the mixer. It is used extensively in the construction industry to produce concretes, grouts and mortars.

Reaction Mechanism

The hydration mechanism of a combination of ggbs and Portland cement is slightly more complex than that of a Portland cement. This reaction involves the activation of the ggbs by alkalis and sulfates to form its own hydration products. Some of these combine with the Portland cement products to form further hydrates which have a pore blocking effect. The result is a hardened cement paste with more of the very small gel pores and fewer of the much larger capillary pores for the same total pore volume. Generally, the rate of strength development is slower than for a Portland cement mortar.

Ggbs Utilisation

Ggbs has been used in mortars for many years in ready-to-use retarded mortars and the dry silo system. Typically, ggbs has been used at between 25 and 50% replacement of the Portland cement with or without the addition of lime.

Specification

Factory made cements should conform to the requirements of BS EN 197-1 Common cements: CEM II/A-S, CEM II/B-S or CEM III-A. Combinations should conform to the requirements of BS 8500-2:2006:Annex A for Type CII-S or CIIIA.

Use with Admixtures

Where retarding admixtures are used to produce ready-to-use retarded mortars the incorporation of ggbs reduces the dosage rate required to achieve the desired level of retardation. The degree of reduction is

retardation. The degree of reduction is dependent on the proportion of ggbs used, however, trials indicate that a 35% reduction can be achieved with high proportions of ggbs.

Efflorescence

The pozzolanic secondary reactions associated with the hydration of ggbs utilise some of the excess calcium hydroxide in the pores and may reduce the risk and extent of any efflorescence.

Fly Ash

Production

Fly ash was historically known as pulverized fuel ash in the UK, it is a by-product from the burning of pulverized coal in power stations. It has both pozzolanic and physical properties that enhance the performance of mortars. In some parts of Europe natural pozzolanas are available; these are composed of volcanic ashes and their use goes back to Roman times.

Reaction mechanism

Due to the mineralogical composition of the coal used, some fly ashes produced within Europe may have latent hydraulic properties in addition to pozzolanic properties. The majority of UK ashes do not.

When Portland cement hydrates it produces alkali calcium hydroxide (lime). Pozzolanas such as fly ash can react with this lime to form stable calcium silicate and aluminate hydrates. These hydrates fill the voids within the mortar matrix, thus reducing the permeability and the potential for efflorescence. Additionally, the reduction in the quantity of lime remaining further decreases the occurrence of efflorescence. This process improves the strength, durability, chloride and sulfate resistance of the mortar.

The addition of fly ash to a mortar, either as a cementitious material or as an aggregate, normally results in a reduction in the quantity of water required for a given level of consistence. Mortars containing fly ash have improved fresh properties, in particular, cohesion and resistance to segregation and bleeding. Furthermore, they will tend to have a slower setting time which is advantageous in warmer weather conditions.

Specification

Typically up to 35% of fly ash is permitted, whether in the cement produced at the cement works or blended as an addition at the mixer. Factory made cements should conform to BS EN 197-1 (Common cements: CEM II/B-V or BS EN 413-1). Mixer blended cements should be made with BS EN 450 fly ash and conform to the requirements of BS 8500-2: 2006 Annex A.

Use with admixtures

Fly ash can be used in ready-to-use retarded mortars, however, some adjustment to the air entrainer dosage may have to be made. An allowance may also have to be made to the retarding admixture dosage to take account of the slower setting time..

Pigmentation

Fly ash is naturally grey in colour, producing a mortar that appears darker and richer in cement. Its use in lighter, pigmented mortars may, therefore, need special consideration.

Efflorescence

The incorporation of fly ash in a mortar assists in the reduction of efflorescence. This is because it reduces the permeability and reacts with some of the free calcium hydroxide as discussed under 'Reaction mechanism' opposite.

References	
BS 8500-2	Concrete - Complementary British Standard to BS EN 206-1
BS EN 197-1	Cement composition, specification and conformity criteria for common cements
BS EN 413-1	Masonry cement: Composition, specifications and conformity criteria
BS EN 450-1	Fly ash for concrete.
BS EN 998-1	Specification for mortar for masonry: Part 1 - Rendering and plastering mortar
BS EN 998-2	Specification for mortar for masonry: Part 2 - Masonry mortar
BS EN 15167-1	Ground granulated blastfurnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria.

mpa
essential materials
sustainable solutions

MPA Mortar is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries.

Mineral Products Association Ltd
First Floor
297 Euston Road
London NW1 3AD
Tel 0203 978 3400
mick.russel@mineralproducts.org
www.mortar.org.uk

Factory produced mortar products will contain either cement or lime, both of which have properties which are hazardous to health. Please refer to the manufacturers or suppliers Material Safety Data Sheet for the specific product/grade to find more information on the nature of the hazardous properties, the risks and health effects of exposure and the recommended safe use and handling procedures.